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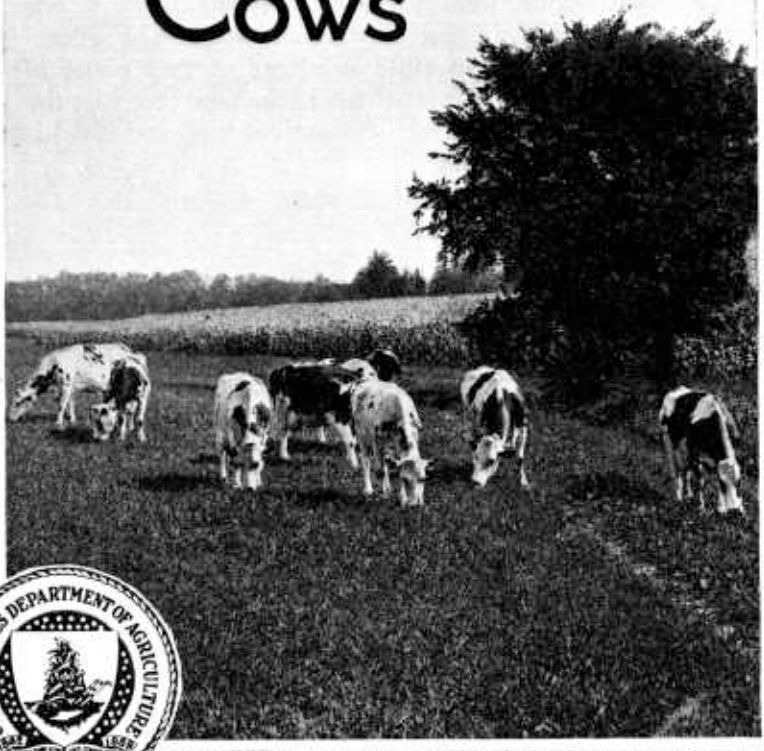
Feeding Dairy Cows



THE FEED of the dairy cow constitutes about one half the expense of milk production. Profitable milk production, therefore, demands close attention to the matter of feed. The ration must be adequate in quantity, suitable in quality, but as low in cost as possible. The quantities of feed to be given the cow for most economical production have been determined with a fair degree of accuracy. The object of this bulletin is to state in simple terms some of the principles of dairy-cow nutrition and to assist the dairyman in preparing economical rations for his cows.

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FEEDING DAIRY COWS

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CONTENTS

HOW A DAIRY COW USES HER FEED

THE RATION of a dairy cow is used for five main purposes, namely, maintenance, growth, body fat, development of fetus, and milk production.

A maintenance ration is an amount of feed equivalent to that needed to keep the cow at constant weight when not giving milk or carrying a calf. It is used to keep the vital organs functioning properly, to replace worn body tissue, to maintain body temperature, and to provide energy for muscular activity, such as standing or moving about. The maintenance ration must be considered somewhat as a necessary overhead expense. Apparently none of it, except perhaps some of the protein, contributes anything toward economic production; yet, as a general rule, it is the first to be used by the cow and certainly should be the first to be considered in compounding a ration.

An immature animal uses a portion of its feed for growth. For this reason it needs a larger ration than a mature animal of the same weight. The ration for growth requires somewhat more protein than does the maintenance ration.

The feed needed for body fat is of no considerable consequence except during the time when the cow is dry or nearly so; at this time she is storing up a reserve to be used after calving.

When the cow is carrying a calf she needs extra feed to provide for the development of the fetus and the membranes and fluids coexistent with pregnancy. The quantity of feed required for these purposes is not large but is sufficient to be considered.

Just after calving, and for 3 to 6 weeks thereafter, high producers do not consume sufficient feed to supply the nutrients needed for milk and for maintenance, and as a result they lose weight. Liberal feeding is desirable but only to the point of supplying the nutrients the cows can use without undue waste.

IMPORTANCE OF THE VARIOUS FEED CONSTITUENTS

PROTEINS

Proteins in the feed are used to make the proteins of milk, blood, lean meat, and all nitrogenous body tissues. They are used in the repair of parts broken down in the ordinary course of bodily activities. For the purposes enumerated no other constituent can take their place. In addition to these uses proteins can also be employed in making fat and providing energy.

Proteins are made up of various amino acids. If a cow is to produce all the milk of which she is capable by inheritance she must receive a sufficient amount of each of the various amino acids used for maintenance and milk production. Since different proteins contain different proportions of the amino acids, the cow needs not only an ample quantity of protein but also various kinds of this constituent. This will usually call for the feeding of materials derived from several species of plants. When the constitution of the proteins and the characteristics of the amino acids become better known it may be possible to reduce both the quantity of proteins and the number of the sources from which they are obtained. All feeding standards specify an amount of digestible protein somewhat in excess of that found in milk. A moderate excess is not known to be detrimental to the health of the animal. Furthermore, since the proteins not used for milk production can be used to make fat or energy, they are not necessarily wasted. The fact that in most dairy sections of the United States feeds high in protein are more expensive than those low in this constituent is probably the main reason for using a ration containing the smallest quantity needed for continuous high production.

CARBOHYDRATES

The principal substances in feeds making up carbohydrates are starches, sugars, and crude fiber. These are used to maintain body temperatures, to make body fat and milk fat, and to provide energy for every muscular activity, such as mastication, respiration, and locomotion. Crude fiber is the least digestible of these substances. Feeds containing more than 18 percent of fiber in the dry substance may be classed as roughages, and those containing less as concentrates. Carbohydrates are more plentiful than proteins and are usually cheaper. This is one reason why it is generally unwise to use proteins for any purpose that carbohydrates will serve.

FATS

Fats in feeds are used for the same general purposes as carbohydrates, but on the basis of equal weights of each they are about two and one fourth times as efficient as carbohydrates. They also lubricate the digestive tract and aid in making a glossy coat. Since most

rations probably contain fats in sufficient quantities for satisfactory nutrition, no special consideration need be given the fat content in the preparation of the ration.

MINERALS

Minerals comprise a variety of compounds which exert an important influence on many of the physiological processes of the animal body and are as necessary as the other constituents of the ration. They are used principally to aid digestion, to make bone, to provide the mineral matter in the milk, to build up the body, and to aid in the functioning of all organs in general.

Cows must have feed containing enough minerals of the proper kind or they will draw on their body stores and eventually decline in production. Other ill effects such as stiffness, enlarged joints, lack of appetite, depraved appetite, and cessation of oestrum can sometimes be traced to lack of minerals. In some sections pregnant cows fed rations deficient in iodine are likely to give birth to calves with goiter.

WATER

Water is the great carrier of food material within the body of the animal. It makes blood a fluid so that it can circulate. Many substances must be dissolved in water before they can be absorbed from the digestive tract. Waste materials are dissolved in water and eliminated as urine and perspiration. By its evaporation from the skin and lungs water controls body temperatures. Water, then, is a necessary constituent of practically all excretions or secretions, including milk. Animals will live much longer without food than without water.

VITAMINS

The term "vitamin" is a group name for certain substances, other than proteins, fats, carbohydrates, and minerals, which have been discovered to be necessary in animal nutrition. These vitamins occur in minute quantities in natural food materials. Those studied have been named A, B, C, D, E, and G. Vitamin B is sometimes called B_1 or F, and vitamin G is sometimes called B_2. Both of these vitamins were formerly called B. The vitamins are not chemically determined but are recognized by their physiological effect rather than by their physical and chemical properties. Vitamins are essential to the life and health of animals.

Vitamin A appears to be the one most likely to be deficient in the ration of the dairy cow. This vitamin controls growth and influences resistance to infections. Carotin, one of the yellow pigments of the plants from which vitamin A is formed in the animal body, occurs in close association with the green coloring matter of pasture plants and other green forage and also with the green coloring matter of cured roughages, though in carrots and yellow corn it occurs in dissociation with the green color. As a rule the greener the color of the feed the greater is the content of carotin. Green forage is the common source of vitamin A for cows, but cod-liver oil is often fed to certain smaller animals to provide vitamin A.

Cows fed for extended periods on a ration deficient in carotin may give birth to weak, dead, or premature calves. Whether this result

is due entirely to a deficiency of vitamin A has not been definitely determined. Although the quantity of milk produced by cows fed on a carotin-deficient ration may not be materially affected, the content of vitamin A in the milk is much reduced. Calves fed the milk from cows that have been on a carotin-deficient ration for some time will cease to grow and will soon die unless they are given supplementary feeds rich in vitamin A or carotin. A reserve supply of vitamin A is stored in the liver and, on account of this, cows may sometimes go for months on a ration deficient in vitamin A or carotin without any noticeably bad effects.

Vitamin D or some unidentified property of pasture grass, or of other green forage, or of hay cured with much of its natural green color, is useful in promoting the assimilation of calcium and the retention of calcium within the animal body. The other vitamins, if actually essential to the proper nutrition of dairy cows, have never been proved to be so deficient in any of the ordinary rations that their lack causes trouble, though it is possible that a vitamin or other dietary factor plays an important part in promoting conception by dairy cows and heifers.

Pasture grass or other green forage, or a hay that has retained much of its natural green color, fed for at least a portion of the year, is essential to the continued well-being of dairy cows. Otherwise cows will suffer from a vitamin A deficiency and possibly also from a mineral deficiency.

PROCESS OF DIGESTION

The cow's stomach is divided into four compartments. Apparently cows chew their feed and mix it with saliva only enough to permit it to be swallowed into the large compartment of the stomach known as the rumen or paunch. This compartment acts as a reservoir and softens the coarse feed through the action of body heat and mixing with water. It appears also that the action of certain bacteria in the paunch may be beneficial.

Cows chew their cud and thus further reduce the size of the feed particles so that they may pass to the other compartments of the stomach. Any feed that is in a sufficiently fine state of division may pass on directly without being rechewed. The paunch is never empty; additional feed enters every time a cow eats, and the new and old materials are mixed. Although some of the roughage, such as hay, passes through the digestive tract in about 1½ days, some of it remains in the body for 10 days or more.

The next compartment of the stomach is known as the reticulum or honeycomb. Its contents are more watery than those of the paunch. Foreign material, such as gravel and pieces of metal, collects here and remains. Sometimes a sharp piece of wire or nail penetrates the wall of this compartment, with fatal results.

The third compartment is called the omasum or manyplies. Across it are divisions resembling leaves of a book, and it is between these leaves that the food passes. The contents of this compartment are much drier than those of the others.

Although some absorption of nutrients into the blood takes place through the walls of the first three compartments, the main function

of these compartments appears to be the preparation of the food for the action of the fourth and last compartment, or true stomach, known as the abomasum. It is here that the digestive juices act on the proteins and convert some of them into a state in which they can be absorbed through the walls of the stomach.

The food then enters the intestines, where it is further acted upon by the bile, pancreatic juice, and other juices, which digest the fats and carbohydrates as well as some of the proteins. Most of the food absorption takes place through the walls of the intestines.

CHARACTERISTICS OF FEEDS

Feeds differ considerably in composition. One lot of hay, for example, may contain a high percentage of the food constituents needed by the animal, whereas another lot of the same kind of hay and from the same cutting, but grown on a different part of the field or cured and handled in a different manner, may contain a low percentage of these food elements. The dairyman may find also that whereas his cows have done well on a certain cutting of alfalfa, a sudden change to another cutting causes a decrease in the milk flow. Sudden and extreme changes in the ration, such as from all-dry feed to all-green feed or from a low-protein to a high-protein ration, may cause a temporary change in percentage of butterfat.

Variations in the composition of feeds, however, generally affect the quantity of milk production rather than the composition of milk. Feeding a ration rich in fat, for instance, does not permanently increase the percentage of butterfat in the milk, for this percentage, like that of other constituents of milk, is largely a matter of inheritance.

HAYS

The importance of good hay can hardly be overestimated. By good hay is meant hay that has been cut early and cured with the retention of much of its natural green color. Such hay contains more protein, less fiber, more carotin, more leaves, and fewer stems than hay cut late. It is also softer and more palatable. The mineral matter of green-cured hay is more completely used than that of hay which has become discolored through exposure to dew or rain.

Although legume hays are generally superior to the nonlegumes in content of protein and mineral matter and in palatability, much depends upon the soil on which the hays are grown and on the way in which they have been made. A grass hay, for instance, grown upon a soil that is rich in lime and phosphorus, cut early, and nicely cured, may be superior in many respects to a legume hay. A legume hay is not necessarily good merely because it is a legume, nor is a grass hay necessarily poor because it is a grass.

All dairymen, whether they raise their own hay or buy it, should be able to determine, by observation, the quality of the various classes and grades of hay, as given in the United States Department of Agriculture Handbook of Official Hay Standards, for 1928.

The following statement [1] made with reference to alfalfa-hay production and marketing may be applied in general to all hays:

[1] U.S. Department of Agriculture, Bureau of Agricultural Economics. U.S. Standards Reflect the Approximate Value of Alfalfa, 5 pp. 1927. [Multigraphed.]

(1) Early cut, leafy, and properly cured alfalfa from any region has more feed value than overripe, stemmy, and properly cured alfalfa from the same region or any other region; (2) alfalfa from any region, so cured as to retain a high percentage of leaves, has more feed value than alfalfa from the same region or any other region that was so cured as to shatter a high percentage of leaves from the stems prior to baling; and (3) early cut, leafy, and properly cured alfalfa from any region has more feed value than early cut, severely bleached, and rain-damaged alfalfa from the same region or any other region. Similar comparisons and conclusions may be made with respect to the feed value of various cuttings.

LEGUME HAYS

Legume hays appear desirable for the proper nutrition of the dairy cow when pasture or other green feed is not available. In most sections of the United States they yield more nutrients per acre than do nonlegumes and provide protein at a lower cost. Good legume hay is cured so as to retain its green color, is fine stemmed, and contains a large proportion of leaves to stems. Forty-four pounds of alfalfa leaves contain as much protein as 100 pounds of stems. For supplying vitamins, good legume hay and silage take the place to some extent of fresh, green forage.

Alfalfa is the best hay for dairy cows (fig. 1). It is more palatable than clover, is more easily cured than the annual legumes, and when fed, is more completely consumed than is either soybean or cowpea hay. Wherever alfalfa grows succesfully it should be raised in preference to any other legume.

Although cows will eat no more of the clovers than they will of the annual legumes, there is usually less waste in feeding the clovers on acount of their finer stems. Because of their fine stems also they cure more readily, and are therefore less liable to damage from rains. The clovers are rather uncertain crops. The stand is sometimes poor, and they are subject to winterkilling. No doubt this fact is responsible for the usual practice of seeding timothy or other grass along with the clover for if the clover fails the grower still has timothy.

Either soybeans or cowpeas can be raised successfully over a wide range of climatic and soil conditions. They grow on soils containing less lime than will the clovers or alfalfa, and they are especially valuable as catch crops for hay. Soybeans, being more upright in their growth and thus more easily harvested, are usually preferred to cowpeas.

The Lespedeza hays, both common and improved varieties, are coming into more general use in the South, especially on acid soils. They make excellent hay, and some very good yields on rich soil have been reported.

The first year's growth of the biennial sweetclover makes a very good hay. If allowed to reach considerable height before being mowed, however, it will be stemmy, and the leaves will shatter badly. The second year's growth should be used for pasture rather than as hay for the following reasons: (1) It grows so rapidly that in order to get a reasonably fine hay it must be cut very early in the season, when curing is difficult; and (2), while many farmers have successfully fed second year's growth for a long time, there are recorded instances in which such hay contained some substance that pre-

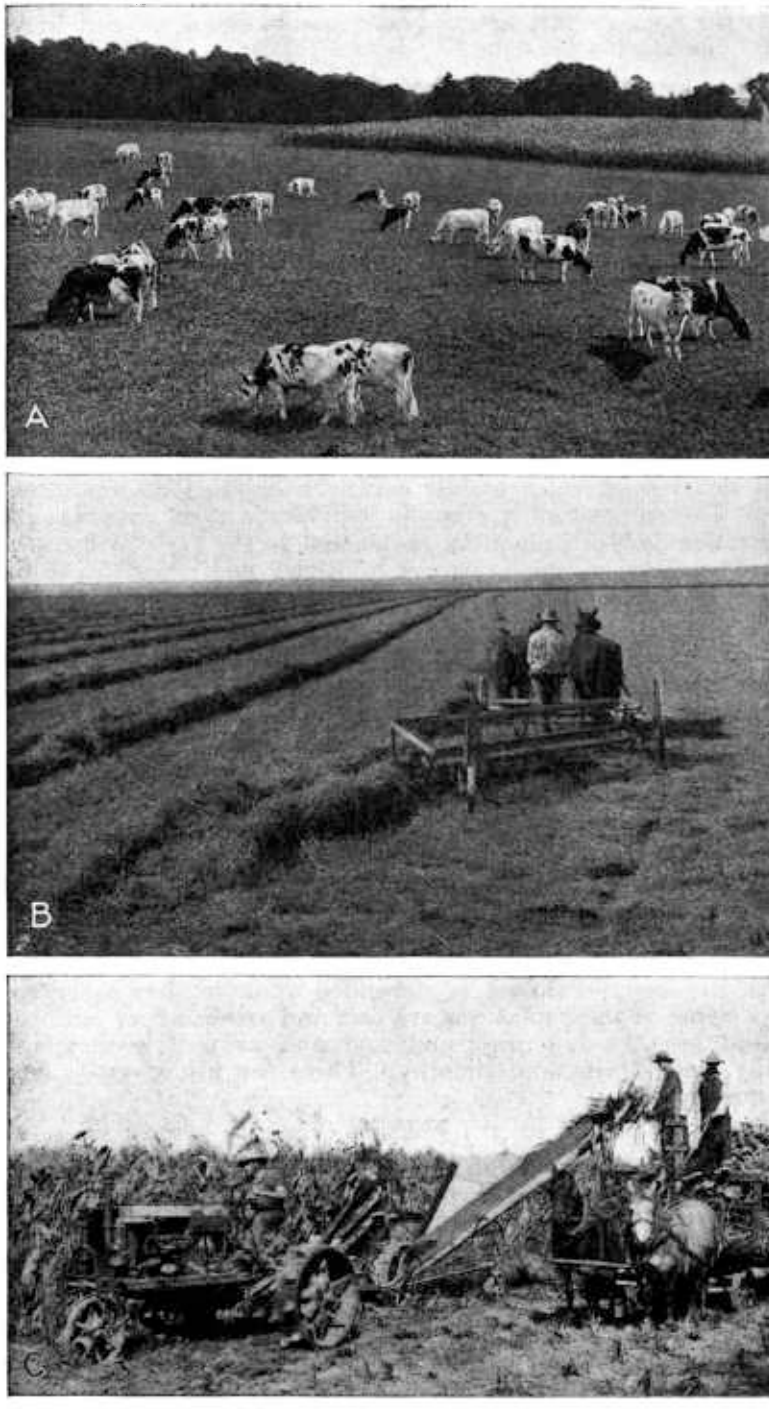

FIGURE 1.—Three sources of cheap feed for dairy cows: A, Pasture; B, alfalfa; C, corn for silage.

vented the normal clotting of blood from a wound and led to fatal hemorrhages in the animals.

GRASS HAYS

Grass hays include timothy, ryegrass, bluegrass, Sudan grass, sorghum, and others. As a rule these hays are less palatable than legume hays and contain less protein and mineral matter, and therefore are not so good as legume hays for milk production. However, if the grass hays are harvested at an early stage of maturity and are properly cured, they may be equal to ordinary legume hay in both palatability and content of protein.

GRAIN HAYS

Grain hays include those made from the small cereals, such as oats, barley, wheat, and rye. To make the best hay these cereals should be cut when the grain is in the milk. At this stage the cured leaves retain their green color and if carefully handled do not crumble badly. In composition the grain hays are similar to grass hays, being rather low in protein in proportion to the carbohydrates and fats. The awns on some varieties of barley and wheat make these hays decidedly undesirable for feeding.

MIXED HAYS

Although the Handbook of Official Hay Standards gives a specific definition of mixed hay, for the purpose of this discussion any combination of a grass and a legume is called a mixed hay. Its composition is influenced by the kind and relative quantities of legumes and nonlegumes which it contains, the stage of maturity when cut, and the manner in which it is cured. Although early cut grass often contains as much protein as the legumes, it is safe to conclude that, on an average, mixed hays contain only about two thirds as much protein as do the legumes.

The practice of using a mixture of legumes with some other crops is to be commended where because of soil conditions or habits of growth the legumes cannot be depended upon for hay when sown alone. Some of these mixtures are oats and vetch, wheat and vetch, oats and peas, Sudan grass and soybeans, as well as clover and timothy, and alfalfa and timothy. These can all be made into a good quality of hay.

STRAWS

The cereal straws are high in fiber, low in proteins and minerals, constipating, and lacking in palatability. Cows, however, will eat small quantities of these, especially oat straw, even when they have access to plenty of legume hay. Probably the consumption of a small quantity is beneficial.

CORN STOVER

The edible portion of corn stover is similar to timothy or other grass hay in composition, effects, and value. If the corn is cut rather early and the stover is stored where it will not be leached by the fall and winter rains, it makes a fair feed. Even when carefully

cured, however, it lacks the nutritive qualities desired in dairy feeds. Straws and corn stover must not be expected to take the place of legume hays in the ration.

SILAGES

All silages are succulent, some are palatable, and some provide nutrients in a cheap form. All things considered, corn makes the best silage. It is very palatable, though low in protein and minerals. Other nonleguminous silages, such as sorghums and Sudan grass, are a little less palatable and contain less nutrients. Legumes with a water content between 50 and 70 percent are successfully ensiled. To reduce the moisture content to the proper point it is often necessary to let them wilt thoroughly after mowing. They are higher than corn silage in protein and mineral matter but not so palatable. Sunflowers and certain other plants make silages that are less palatable than corn silage.

SOILING CROPS

Soiling crops, which are harvested and fed immediately in their fresh green state, are valuable as substitutes for pastures or as supplements to them. A cereal, Sudan grass, or a legume, or a combination of the cereal or Sudan grass with a legume, is most commonly used, but any palatable green feed may be fed. Soiling crops are similar to pasture in nutritive value.

ROOT CROPS AND OTHER SUCCULENTS

Most of the common root crops, such as mangels, beets, rutabagas, turnips, and carrots, are valuable dairy feeds. Because they are low in fiber and high in water content these feeds are sometimes spoken of as watery concentrates. Materials which may be fed in the place of silage or the root crops are apples, apple pomace, pumpkins, cull potatoes, sweetpotatoes, kales, sugar-beet pulp, and wet brewers' grains. The value of each depends largely upon the content of dry matter. Wet beet pulp and pumpkins are low in this constituent, having only about one-third as much dry matter as sweetpotatoes and wet brewers' grains.

PASTURE

Pasture grass or other green forage appears desirable for continuous high milk production. Such material possesses a property which under certain conditions promotes the assimilation of mineral matter. A cow on good pasture is able to replenish the stores of minerals and vitamin A which are likely to have become depleted during the winter if an unsuitable grain mixture and a poor quality of roughage have been fed. Since pasture grass is bulky and watery, most cows are unable to eat enough of it alone to support a very large flow of milk. As the grass matures there is a steady decline in the percentage of protein and an increase in the content of dry matter and fiber.

CEREAL GRAINS

In general, cereal grains are palatable, rich in carbohydrates, low in fiber and minerals, comparatively low in protein, and high in total digestible nutrients. Corn stands at the head of the list in palatability and percentage of total digestible nutrients. Barley and the

sorghums are almost as high in these respects. Oats have a higher fiber content than any of the other cereals but contain more protein than does corn or barley. Wheat is similar in composition and feeding value to corn, and when the price of wheat per pound is less than that of corn it will pay to substitute wheat for at least a part of the corn in grain mixtures for dairy cows. Rye is high in content of nutrients, but because it lacks palatability it is used very little as a dairy feed.

LEGUME SEEDS AND OIL MEALS

The legume seeds and so-called oil meals contain much protein and have a high nutritive value. The legume seeds used for dairy feed include the field pea, velvetbean, soybean, and peanut. The oil of the soybean and peanut is usually extracted and used commercially, the residue being used for feeding purposes. In that form they are similar in feeding value to linseed meal and cottonseed meal, which are also residues from the extraction of oil from the flax and cottonseeds, respectively. All these feeds except the velvetbean are palatable, but their high concentration makes it desirable that they be fed with more bulky material. Cottonseed meal contains a comparatively large percentage of phosphorus, linseed meal and soybean meal somewhat less, and peanut meal the least of all.

BYPRODUCTS

A number of byproducts are used for feeding, but only the most important ones are discussed here.

Wheat bran contains much phosphorus, a medium amount of protein, and is bulky. These characteristics make it a valuable ingredient of all dairy rations.

Hominy feed is comparable with corn meal in nearly all respects. The two are thought to be equal in feeding value pound for pound. Hominy feed is not so likely to heat and mold as is corn meal.

Corn-gluten feed is rather high in protein, averaging 20 percent or more in the best grades. It is somewhat bulky and not quite so palatable as hominy feed and corn meal.

Dried brewers' grains are similar to corn-gluten feed in composition, but they contain more fiber and less total nutrients.

Dried beet pulp is low in protein, bulky, and fairly palatable. Apparently cows are unlikely to be injured by eating too much beet pulp.

Both beet and cane molasses are very palatable and when mixed with some feeds ordinarily unpalatable cause them to be eaten more readily and completely. About two thirds of the weight of molasses is sugar. Sometimes the price of molasses is so low that some feeders consider that the nutrient content alone justifies its purchase. Both kinds of molasses are laxative, that from the sugar beet being more so than that from the sugarcane.

COMMERCIAL MIXED FEEDS

Many excellent mixed feeds containing only high-quality ingredients are on the market. Laws governing the sale of mixed feeds require that their chemical composition be stated on the bags. An examination of these analyses will enable the buyer to form a better

opinion of the value of the feed. The lower the fiber content the more valuable the feed. A high fiber content indicates the presence of oat hulls, corncobs, cottonseed hulls, ground roughage, or other low-grade material. The analyses of many mixed feeds, however, do not give complete information on the composition—omitting the sources of protein, for instance, or the content of phosphorus and calcium. Such formulas are known as "closed" formulas. The "open" formula, on the other hand, gives also the kind and quantities of the different ingredients in the mixture and thus helps the buyer to judge the value of the feed. If the analysis of a feed is satisfactory, if the variety of sources is ample, if the odor and appearance of the feed are good, and if the cows like it, the requirements for a good feed are largely complied with.

COMPOUNDING THE GRAIN RATION

In compounding the grain ration several factors besides cost must be considered. They are bulkiness, palatability, and the content of protein and minerals.

PROTEIN CONTENT

One of the most important considerations in preparing a grain ration is to see that it contains sufficient protein from a number of sources so that every cow will be amply nourished. It is impracticable, however, to furnish a perfectly balanced ration for each dairy cow in the herd because the requirements of the cows differ with their production. It is better to have some cows get more protein than they need than to attempt to supply a perfectly balanced ration for every cow. The quantity of protein that must be supplied in the grain depends upon the quantity of protein in the roughage. The approximate percentages of protein in the grain rations to be fed with different roughages are shown in table 1. There are hundreds of combinations that may be used; the mixtures shown in the table are made up of certain standard feeds. Other feeds may be substituted wholly or in part for the feeds specified.

TABLE 1.—*Grain mixtures having different protein contents to be fed with different roughages*

Roughage	Approximate protein content desired in grain mixture	Grain mixture			
		Ground corn	Ground oats	Wheat bran	Cottonseed meal
	Percent	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Legume hay alone	12	400	200	200	
Legume hay and silage or mixed hay [1] alone	16	300	200	200	100
Mixed hay [1] and silage	20	200	200	200	200
Grass hay and silage or either alone	24	100	200	200	300

[1] One half grass and one half legume.

Part or all of the corn in the mixtures in table 1 may be replaced by barley, wheat, kafir, spelt, or hominy feed. Part of the oats may be replaced by barley, wheat, kafir, spelt, hominy feed, or corn.

Two parts of gluten feed or dried brewers' grains may replace one part of oats and one part of cottonseed meal. Linseed meal, peanut meal, or soybean meal may be substituted for part or all of the cottonseed meal.

MINERAL CONTENT

The minerals most likely to be deficient in the ration are common salt, calcium (lime), and phosphorus. Add common salt to the grain mixture at the rate of 1 percent. In addition to this allow the cows access to salt at least once a day.

Although mineral mixtures are sometimes added to the grain ration, better results are obtained by making up the ration in such a way as to supply the needed minerals in the natural foodstuffs. None of the concentrates are high in lime. To provide this mineral, see that the cow receives plenty of legumes either in the form of pasture, soiling crops, or well-cured hay. If the grain ration contains a liberal proportion of wheat bran or some of the oil meals the phosphorus needs of the cow will be met. Soils containing an abundance of lime and phosphorus will produce forage richer in these constituents than will soils deficient in them. For this reason liming and fertilizing the soil will go a long way toward maintaining proper mineral nutrition of the dairy herd.

Feeding inorganic mineral supplements containing calcium and phosphorus is advisable only under certain conditions. When cows are on grass pastures, especially if the soil is poor in lime or phosphorus or both, some benefit is derived from feeding steamed bone meal. Mix it with the grain at the rate of 1 or 2 percent. If the cows receive no grain while on pasture, put the bone meal in a box where it will be accessible to the cows. In certain sections of the United States the soil is so deficient in phosphorus that feeding the forage produced thereon to dairy cows in the winter leads to serious malnutrition. This may be corrected by feeding steamed bone meal.

Steamed bone meal is valuable as a source of both calcium and phosphorus. Some bone meals are steamed more than others. The more the meal is steamed the less the organic matter left in it and the less odorous the product. The cows greatly prefer the bone meal which has been only slightly steamed, and for this reason it is the better form to use where cows have access to it at will. In any case the bone meal should be steamed sufficiently to destroy any disease-producing organisms. Since such bone meal spoils when it gets wet, the box containing it must be protected from the rain. When the bone meal is fed in the grain mixture its palatability is not a factor and therefore it makes no difference which form of the product is used.

The use of complex mineral mixtures is not advised, since calcium and phosphorus, the only minerals likely to be deficient in the ration, can be obtained more cheaply in bone meal than in the prepared mixtures. Raw rock phosphate may prove harmful because of its content of fluorine.

In addition to the minerals just mentioned, it is sometimes necessary in certain regions to supply iodine in the ration. This can be done effectively by sprinkling on the feed of the pregnant cow once each week a tablespoonful of a 5 percent solution of potassium or sodium iodide.

BULKINESS AND PALATABILITY

Some feeds become pasty when moistened; in this condition the digestive juices cannot readily act on them. Combine such feeds with more bulky ones in order to prevent this condition. The best feeds for this purpose are wheat bran and ground oats. If the grain ration contains one third to one half of either or both of these two feeds it will not stick together when wet. Dried beet pulp or a ground roughage may also be used for this purpose. In some cases the concentrates are mixed with the silage at feeding time. Cobs are sometimes ground with the corn in order to provide bulk in the grain ration. Although the cobs do serve this purpose, they add very little nutriment.

Grain mixtures should be sufficiently palatable so that every cow will consume as much as is required for highest milk production. Fortunately, most concentrates of good quality are palatable. Among these are corn, barley, oats, wheat bran, beet pulp, and the oil meals. Velvetbeans, rye, coconut byproducts, and some of the other uncommon feeds lack palatability.

The use of molasses in a ration that is already palatable is not profitable as a rule. This depends on the cost of the nutrients in the molasses as compared to that of the nutrients in the other feeds. Cows will eat an unpalatable grain mixture more readily and a low-grade hay more completely, however, if molasses is poured over or mixed with the feed. Before adding the molasses, mix with it enough water to make the solution flow freely. Excessive quantities of molasses make the ration highly laxative. Usually 3 pounds per day for each cow is the maximum amount that can safely be fed.

KINDS AND QUANTITIES OF FEED TO USE

In general, dairy cows should be fed all or nearly all the roughage they will consume in the form of pasture grass, soiling crops, hay, or silage. If such feeds are home grown, the nutrients in them are usually cheaper than those in concentrates; the cow's digestive system is primarily adapted to handling coarse feed, and cows generously fed on roughage rather than concentrates are less subject to digestive disturbances. If the dairyman buys both the hay and the grain, however, and the hay costs more than one half to two thirds as much as the grain, he may well limit the quantity of hay and feed more grain. In feeding medium- or low-producing cows, such feeding practice is safe and economical; in feeding high producers, however, care must be taken not to feed concentrates too heavily and throw the cow off her feed. Such cows should receive enough nutrients in their roughages so that the grain allowance may be kept at a safe level. On the other hand, cows producing a small or medium quantity of milk may be fed on roughage alone if the roughage is of good quality and relatively cheap.

SUMMER FEEDING

Ideal pasture herbage is young, tender, abundant, palatable, and grown on a soil rich in minerals, especially lime and phosphorus. Immature grass not only has a higher protein content but also is more palatable than that which has reached the usual haymaking

stage. In many pastures cows will graze on the spots of short grass rather than on the grass that has become more mature. Early in the spring, although the grass is tender and palatable, it should not be grazed until it has made enough growth so that a cow can gather her fill in a few hours.

Pastures differ so much in quality that specific pasturing recommendations are impossible. On a good grass pasture cows that are producing 1 pound of butterfat or less a day maintain their production and body weight for the first six weeks or so just as well without grain as with it. But from this time until fall additional feed must be supplied because the growth of grass becomes slower, the weather warmer, and the flies more annoying, and these factors combine to cause a much-diminished intake of grass. If the rainfall is sufficient to keep the pastures fairly abundant or if temporary pastures are available, grain alone will probably suffice as a supplementary feed. Under less favorable conditions, however, soiling crops, hay, or silage must also be fed. Exceptionally good pastures will support a production of more than 1 pound of butterfat a day.

In deciding on the kinds and quantities of feeds to be used in supplementing the pastures, the condition of the cows should be taken into consideration. In most cases, if the cows are allowed to become very thin, the result will be a much-reduced milk flow, which cannot be regained during that lactation period by subsequent more liberal feeding.

Soiling crops are often used as supplements to short pastures and sometimes as substitutes for them. For the former purpose corn and, to a lesser extent, alfalfa, soybeans, or Sudan grass are the most generally used. Since these crops are rather generally raised on dairy farms, they require no additional fields or attention. Therefore, they make the cheapest and best soiling crops for use in the late summer. When soiling crops take the place of pasture entirely, a continuous supply of them must be provided throughout the summer, a fact that necessitates special crops or special seedings to fill the gaps between the crops regularly raised. The crops to be raised differ so much with climatic and soil conditions that specific recommendations for them are not possible.

For summer feeding, silage, where it is available, is generally cheaper and more convenient to use than are soiling crops. Silage left over from the previous season may be fed after the spoiled top layer has been removed, or an early-maturing crop may be ensiled and used as needed. Hay may also be used to supplement pastures, particularly if the nutrients in the hay are obtained at a relatively low cost.

WINTER FEEDING

In winter the cows should be given all the good hay they will eat, twice a day. If they will eat corn stover or straw in addition, there is no objection to letting them have it. When the hay is fed with a medium quantity of silage, 1 to 1½ pounds a day of medium to good hay for each 100 pounds of live weight will be consumed. The same quality of hay fed without the silage will be eaten at the rate of 2 pounds a day for each 100 pounds of live weight. More nutrients are consumed when silage or roots are fed with the hay than when

hay is fed alone. No. 1 alfalfa hay, fed as the sole ration and to the limit of the cows' appetites, will be consumed at the rate of about 3 pounds of day for each 100 pounds of live weight.

In most sections of the United States the silo is the cheapest, surest, and most satisfactory means of providing a succulent feed for winter use. Where corn grows well it is the best crop for silage. It yields heavily and makes a very palatable silage. In some sections of the South and in the Southwest, some of the sorghums produce a yield sufficiently greater than the yield of corn to more than offset the better quality of the corn silage. In sections too cold for the good growth of corn, oats and peas grown together or sunflowers make a fairly satisfactory substitute. Mixtures of corn or sorghum and a legume are desirable for silage only when the legume cannot be properly cured into hay. A mixture of corn and soybeans does not make a more palatable silage than corn alone, nor do the two crops grown together yield any more than corn alone. Besides, legumes can generally be made into hay more cheaply than they can be ensiled.

The amount of silage to be fed ranges from about 20 pounds per cow per day to 50 pounds per cow per day, depending on the size of the cow and the quantity of other roughages fed. If hay is scarce or high priced, reduce the amount of hay and feed more silage. The usual quantity of silage advised is about 3 pounds per day for each 100 pounds of live weight.

Although root crops are low in fiber, they should not be fed in place of concentrates but, like silage, as a supplement to a ration of hay and concentrates. The quantity of root crops to feed depends upon their cost as compared with that of other feeds, upon the kinds of roots, and upon the other ingredients in the ration. In general cows receiving some other succulent feed, such as pasture, soiling crops, or silage, do not need root crops. If root crops are expensive, feed only about 30 to 50 pounds a day. If relatively cheap, as may be the case in some regions, feed twice this quantity. More mangels and turnips than sugar beets or sweetpotatoes may be fed because they contain more water. Feed only moderate quantities of beet tops, because they are more laxative than the beets themselves. Beet tops as well as the root crops should be free from excessive dirt when fed.

Frequently the grain requirement for high-producing cows is so great that the necessary quantity cannot be fed without endangering their health. In such cases the quantity of grain may be kept at a safe level and the additional nutrients supplied by feeding beet pulp either dry or soaked in about three times its weight of water.

Experiments at the dairy experiment farm at Beltsville, Md., show the following feeding practice to be fairly satisfactory: Feed each cow about 3 pounds of silage for each 100 pounds of live weight. A cow weighing 800 pounds, therefore, would receive 24 pounds of silage, whereas one weighing 1,200 pounds would receive 36 pounds of silage. Twice a day give the cow all the good hay she will eat, exclusive of coarse stems and weeds. To Jersey cows yielding 10 pounds of milk or less give no grain, but for every pound over 10 give 0.6 pound of grain. A Jersey cow giving 20 pounds of milk,

therefore, would receive 6 pounds of grain; one giving 30 pounds of milk would receive 12 pounds of grain. To Holsteins yielding 16 pounds of milk or less give no grain, but for every pound over 16 give 0.4 pound of grain. A Holstein cow yielding 30 pounds of milk, therefore, would receive 5.6 pounds of grain, whereas one giving 40 pounds would receive 9.6 pounds of grain.

Although this system of feeding has not been tried out with other breeds, it is probable that Guernseys should receive 0.5 or 0.55 pound of grain for each pound of milk above 12 and Ayrshires 0.45 pound of grain for each pound of milk above 14. If the hay is of poor quality the cows will not eat so much of it and therefore must have more grain. On the other hand, if the hay is of the best quality the cows will eat more of it, and less grain than specified will be required. If the roughage is the very best, a cow may produce 1 pound of butterfat daily or even more on roughage alone, without losing weight. The above directions are based on the supposition that the cow eats at least 1¼ pounds of hay per day for each 100 pounds of live weight. In the absence of exact weights, a feeder must be guided largely by the condition of the individual cows. If any are getting thin, give them more grain; if they are getting fat, reduce the grain. For most economical production, cows should be kept in a medium state of flesh, neither fat nor thin.

Record the quantity of feed consumed by each cow. A convenient and practical way to feed concentrates is to use a cart or truck (fig. 2) to which are attached feeding charts or cards showing the amount of feed to be given each cow. A small blackboard can be attached to the cart and the figures recorded. A spring-balance scale suspended above the cart on an arm is of great help. If the allowance of silage and hay is weighed occasionally, the quantity can be measured with reasonable accuracy.

BEFORE AND AFTER CALVING

The cow that has been dry for 6 weeks to 2 months and that has been liberally fed while milking, as well as during the dry period, should be in good flesh at calving time. Several days before the cow calves, reduce the quantity of silage and hay slightly; and if any grain is being fed, cut it down to 3 or 4 pounds daily. Ground oats mixed with wheat bran and linseed meal are good feeds at this time. The drinking water should not be too cold. For several hours before calving, feed the cow very little hay or silage. A warm bran mash at this time is very beneficial.

For a few days after calving, continue to feed sparingly. This will help to prevent digestive disturbances and to reduce the swelling in the udder. In general, after calving the appetite of thin cows is somewhat keener than that of fat cows, and their udders reach normal size in a shorter time. For these reasons the rations of thin cows may gradually be brought to full feed in about 2 weeks and those of fat cows in 4 weeks or more.

After a cow has been fresh from 3 to 6 weeks, her weight has usually reached the minimum and her production the maximum. Feed her enough to maintain her body weight as well as to produce milk; otherwise the production of milk will decrease rapidly. She

should make a slow but steady gain in weight from this time until she calves again in order to bring her to the same condition as that of the previous year. The total gain, including the weight of the fetus, should be from 100 to 250 pounds, depending upon the breed and condition of the cow. It is better to feed her enough to allow some of this gain to be made while milking rather than to try to accomplish it all during the dry period. Such feeding will undoubtedly result in more milk than if the weight is kept stationary. The feeding practice recommended above will furnish sufficient

FIGURE 2.—Concentrates should be fed according to the production of the cows.

nutrients for cows to make a slight gain but still not enough to bring them back to proper weight before drying off. Some of the flesh must be put on when cows are dry.

FEEDING SUGGESTIONS

The order of feeding roughage, succulents, and concentrates has no effect on milk production.

Feed concentrates as often as the cow is milked. Roughage and succulents may be fed twice a day.

Feeding concentrates wet has no advantage over feeding them dry.

Always grind or roll grain for dairy cows.

Beet pulp may be fed either dry or soaked. If water is added, soak at one time only as much pulp as can be fed in 24 hours.

Cows will eat more of a coarse, stemmy hay if it is run through a cutter, although the digestibility of the feed is not affected.

There is no advantage in mixing ground roughages and ground concentrates except that a small quantity of ground roughage may be used to lighten a heavy ration of concentrates.

Corn fodder cut and treated with a converter, which changes some of the starch to sugar, has been found to possess no advantage over corn silage in cost, palatability, or effect on quantity of milk produced.

Always feed highly flavored feeds just after milking. It is advisable to do all the feeding at this time.

Immediately after a cow has calved, give her a small quantity of a warm bran mash.

Before feeding such feeds as root crops, potatoes, and apples, run them through a feed chopper.

Shredding corn stover adds to the convenience in feeding and makes it better bedding.

A cow not in good condition because of disease may be helped by a tonic. The tonic is a medicine and should be used as such. A healthy, well-fed cow needs a tonic no more than a healthy person needs medicine.

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